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14. ABSTRACT
Organic electro-optic materials have been prepared in quantity in support of prototype device development efforts at the University of Southern California and at industrial and government laboratories. In addition to preparing quantities of materials appropriate for device fabrication efforts, a systematic improvement of electro-optic materials has been carried out. Properties such as electro-optic activity, optical loss, processability, and stability have been systematically improved to the point that organic electro-optic materials equal or exceed the performance properties of inorganic materials.

15. SUBJECT TERMS
Electro-optic materials, electric field poling, reactive ion etching, high bandwidth modulators, materials integration, high hyperpolarizability, electro-optic devices

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REVIEW OF OBJECTIVES

The primary object of this research contract is to provide adequate supplies of organic electro-optic materials to permit the fabrication and evaluation of prototype devices. Devices will be fabricated in house and will also be fabricated at a number of other academic (UCLA, Univ. of Texas-Austin), industrial (TACAN, Pacific Wave Industries, Radiant Research, Lockheed Martin, etc.), and government (AFRL-Wright Patterson, NIST-Boulder) laboratories. A second objective is to address material issues that may arise in the fabrication of prototype devices. These issues include adequate electro-optic activity, adequate material optical loss, unacceptable processing results such as phase separation, etc.

STATUS OF EFFORT

Kilogram quantities of a number of electro-optic materials have been synthesized, characterized, and processed into device quality thin films. These materials have been provided to Professors William Steier (USC-EE) and Harold Fetterman (UCLA-EE). They have also been provided to a number of corporate and government research laboratories (see transitions). A number of high performance prototype devices have been fabricated and evaluated. Moreover, material properties and processability have been dramatically improved during the course of this research contract. Electro-optic coefficients have been systematically increased to on the order of 100 pm/V at telecommunication wavelengths. Material optical loss values have been systematically reduced to values on the order of 0.7-1.2 dB/cm with even lower values being obtained for a small number of polymer/dendrimer materials. The processability of materials has been fine tuned to permit spin casting and poling of materials with the introduction of minimum processing-associated optical (scattering) loss. Novel processing protocols have been developed that permit the fabrication and post-fabrication trimming of sophisticated 3-D electro-optic circuitry. Integration of polymeric EO circuitry with VLSI seminconductor electronics and with silica fiber optics has also been achieved.

A number of dramatically successful prototype device demonstrations have been achieved including (1) the demonstration of modulators operating to 113 GHz, (2) the demonstration of modulators operating with halfwave voltages as low as 0.8 volt, (3) the demonstration of modulators operating for greater than 1000 hours at 85°C exhibiting stable material electro-optic activity of 60 pm/V at 1.55 microns operating wavelength, (4) the demonstration of polarization-insensitive and in-line modulation, (5) the demonstration of time stretching for frequencies as high as 102 GHz, (6) the demonstration of 100 Gbit/sec analog-to-digital conversion, (7) the demonstration of 100 GHz bandwidth oscillators, (8) the demonstration of high bandwidth spectrum analyzers based on electro-optic modulators, (9) the demonstration of large angle spatial light modulators based on polymeric electro-optic materials, (10) the demonstration of multiple phased array radar schemes based on polymeric EO modulators, (11) the demonstration of optical gyroscopes, and (12) the demonstration of high bandwidth optical switches based on polymeric EO materials.

The accomplishments of this program are well documented in the numerous publications deriving from this research.

Author of over 350 publications; AFOSR Publications Listed below)

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82. L. R. Dalton, "Design and Assembly of Nanostructured Electro-Optic Polymers," Proc. PMSE, 83, 554 (2000).
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PERSONNEL SUPPORTED

Larry R. Dalton, principal investigator
Dr. Mingfei Chen, postdoctoral fellow
Dr. Shane Mao, postdoctoral fellow
Ms. Galina Todorova, graduate research assistant
Mr. Cheng Zhang, graduate research assistant
Ms. Fang Wang, graduate research assistant
Ms. Albert Ren, graduate research assistant

Program Statistics

65. Number of PI and Co-PI involved in the research project: 1
66. Number of Post Doctoral Fellows supported: 2
67. Number of Graduate Students supported: 4
68. Number of other researchers supported: 0
69. Number of publications by PI: 109
70. Number of publications that acknowledge AFOSR support: 87
71. Awards and Honors received by PI: 9

Transitions:

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. Todd McIntyre, Microvision, 425-415-6616, d. For telecommunication and display applications

b. Dalton, Univ. of Washington, b. Electro-optic materials, c. Martin A. Kits van Heyningen, KVH Industries, 401-847-3327, d. In-line fiber telecommunication applications

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. Araz Yacoubian and James H. Bechtel, IPITEK, 760-438-8362, d. Prototype push-pull modulator fabrication

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. Harold Fetterman and Joseph Michael, Pacific Wave, 310-229-009, d. Prototype device fabrication

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. Susan Ermer, Lockheed Martin, 650-424-3131, d. Prototype device evaluation for various defense applications

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. John Zhang, Lumera Corporation, 425-415-6757, d. Telecommunications and data processing applications

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. Jeffery Make and Ray Chen, Radiant Research, 512-471-7035, d. Prototype device fabrication and evaluation

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. William Owens, Teledesic, 425-602-0000, d. Telecommunications (phased array radar) applications

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. Paul Hale and Eric Amis, NIST, 301-975-6681, d. Evaluation of performance characteristics

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. James Grote, AFRL-Wright-Patterson, d. Prototype device fabrication and evaluation

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. David Weymouth, JDS Uniphase, 613-727-1304, d. Optical network applications

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. Geoff Lindsay and Paul Ashley, Navy China Lake and Army Redstone Arsenal, d. Optical gyroscopes

a. Dalton, Univ. of Washington, b. Electro-optic modulators, c. Shane Stutz, Naval Research Laboratory, 202-404-1514, d. Evaluation of prototype modulators

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. Andre Knossen, Univ. of California at Davis, d. Prototype modulator development

a. Dalton, Univ. of Washington, b. Electro-optic materials, c. Jeff Woodford and C. H. Wang, Univ. of Nebraska, d. Materials evaluation

List of Awards

- 2000 Distinguished Alumni Award of Michigan State University
- 1996 Richard C. Tolman Award of the Southern California Section, American Chemical Society
- Paul C. Cross Lectureship, University of Washington, Seattle, WA (1996)
- NASA Lecturer, 54th Frontiers in Chemistry Lecture Series (1995), Case Western Reserve University
- The 1990 Univ. of Southern California Associates Award for Creativity in Research and Scholarship
- 1986 Burlington Northern Foundation Faculty Achievement Award
- NIH Research Career Development Awards (Two Awards; 75-81)
- Camille and Henry Dreyfus Teacher-Scholar Award (75-77)
- Alfred P. Sloan Fellowship (74-77)